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ABSTRACT

When students and teachers talk about the arrangement of the experimental article in science, they usually take for granted a particular set of radically differentiated parts, including the abstract, the introduction, the materials and methods, the results, and the discussion. All handbooks work from this model. The implication of some literature is that the only excuse for breaking this fairly strict set of expected sections is by virtue of reputation. In Jack Selzer's seminal book "Understanding Scientific Prose," he suggests that students have to pay their dues in writing according to the prescribed method before they can deviate from it. However, this impression is misguided. Given the chance to read real scientific articles, students discover that, in the first place, the arrangement varies radically by journal. They discover, for example, that many articles in cutting-edge journals like "Nature" and "Science" are not divided into sections at all but flow from one point to another. By examining how the arrangement of actual scientific articles diverges from the idealized form articulated in handbooks, students begin to gain rhetorical control over their own writing strategies. Students can extend their freedom and control still further by inquiring into what variations and shifts in conventions mean. The way in which the methods section is often relegated nowadays to the end of the article tells students something about the reading patterns, for instance, of practicing scientists. (TB)

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Look, No Methods!:

Transcending the Boundaries of the Scientific Research Article

Read at the Conference on College Composition and Communication,

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This is a paper about how to employ the sociology of scientific knowledge in the science writing class. Or rather, how not to. In the Spring of 1995 I experimented with using Bruno Latour's classic and quirky study *Science in Action* as a core text in my advanced science writing class at Duke University. The result was an unqualified disaster. No student was quite as trenchant as the one who, in an otherwise positive class evaluation, wrote as his sole recommendation for course improvement, "Bag Latour!" — but most were quite negative toward the book. However, I continue to believe that the lessons of Latour and others in the sociology of scientific knowledge can help students become both better scientists and better writers; and while I have indeed "bagged" Latour, I have sought ways for students to get a good dose of his work anyway — "in action," as it were. In fact, I believe that a social constructivist approach can have positive pragmatic effects in what seems perhaps the most prefabricated, nuts-and-bolts, by-the-numbers area of scientific writing: arrangement. My focus here is on the scientific research article, and in particular on one section of this article — the "Methods" — which will be examined in terms of the goals of a science writing course, the limitations of available instructional materials, and the changing context of scientific communication.

When students, teachers, and handbooks talk about the arrangement of the experimental article in science, they usually take for granted a particular set of radically differentiated parts: Abstract, Introduction, Materials and Methods, Results, and Discussion. To this list a few other parts are sometimes added: the title, for example, or the list of authors, or the references, and of course the Figures. But with the exception of this last item, the basic arrangement of the experimental article is seen as a given, a

prefabricated pattern before which the student of scientific writing or the budding scientist is essentially passive. Both Robert Day's classic companion of scientists, *How to Write and Publish a Scientific Paper*, and David Porush's recent *A Short Guide to Writing About Science*, which we are using this year in my class, construct chapters in the same manner and more or less the same order, with titles like "How to Write the Materials and Methods Section." The handbooks all seem to operate by the old motto: A place for everything, and everything in its place.

This deep conservatism is justified in a variety of ways. We are told that the arrangement of the scientific article is rooted in a long and unshakeable tradition of experimental reporting; that journals have their standards, and must retain consistency; and perhaps most importantly, that the arrangement of the research article confirms a powerful and abiding story of how inductive inquiry is undertaken. Take, for example, the section of the scientific research article that usually goes under names such as "Materials and Methods" or "Experimental Design" (more often referred to in casual conversation as "the Methods"). Of the five sections of the classic research report, the Methods seems perhaps the most transparent, the most resistant to rhetorical analysis; it is the section that, more than any of the others, more or less writes itself. After all, it's just a bunch of instructions. The Methods section is the place where the scientific research article most approaches the cold clarity of technical documentation. Again, the guidebooks put the issue in perspective. Porush's *Short Guide*, for example, defines the Methods section as "a straightforward factual summary of the apparatus and procedure by which you performed the experiment, a sort of script." As such a script, the Methods must not be confused with

other parts of the article. All the guides agree that the Methods section should avoid explanation or interpretation, and while other elements of the paper may be combined — most commonly the Results and Discussion — the Methods section must remain separate.

In addition to being transparent and discrete, the Methods is always — so the guidebooks suggest — parked between the Introduction and Results. Here arrangement plays a crucial function in the scientific research article's overall operation. Situated where it is, the Methods intervenes between the moments of question (Introduction) and answer (Results) to tell a detailed story of what was done. It also provides important appeals to a variety of extratextual authorities (corporations that provided the materials, the "lab" and its experimental setup, the "field" and its conditions, previous methodologies). While the Introduction may briefly outline the methods used and the Results and Discussion may refer back to the Methods for support, the Methods section itself tends to reference a world outside the paper, material conditions and history. To adopt a term from Latour, while the Methods is the source of much of a research article's stratification, it is generally not itself stratified. (I will return to the concept of textual stratification in a moment.)

So the arrangement of the research article, according to the standard representation, constitutes a fairly strict set of rules. Scientists who break these rules are able to do so only by virtue of their reputation or the context of their communication. Although not intended, this idea is implicitly supported by several of the pieces in and (ironically?) the arrangement of Jack Selzer's seminal book *Understanding Scientific Prose*, a book which for me announces a new age in how scientific writing may be represented in the classroom. By taking an article that is unusual in the scientific literature

and one that is written by scientists (or, as it turned out, by a scientist) famous for bucking convention, and then sending that article in a baker's dozen different methodological directions, the book implies that Stephen Jay Gould got away with writing "The Spandrels of San Marco" because he's Gould — which, of course, is partly true. Still, Gould and Lewontin's "Spandrels" is a long way from a student report on the relationship of nitric oxide activity to induced lupus in rats, and it would be easy for students to leave Selzer's book with the impression that, although they may aspire to making Gouldian rhetorical flourishes in their own writing, in the meantime they've got to pay their dues, write cookie-cutter articles — abstractintroductionmethodsresultsdiscussion — and wait for a better day or a radical increase in their own reputation.

I believe this impression is seriously misguided. As it turns out, the world of scientific publication doesn't come close to fitting the mechanical outlines of the handbooks. In the first place, arrangement itself varies radically by journal. In my class in the research article, students examine articles from the major journals in their field and compare the features of those articles with the characterizations of the research article in the standard handbook. Once they have learned to distinguish a research report from a review article, they go wild, coming up with some impressive variances. They discover, for example, that many articles in cutting-edge journals like *Nature* and *Science* aren't divided into sections at all, but flow from one point to another; that in number-rich disciplines like genetics and geophysics, the full results may only be available in a gene sequence warehouse or on the Internet; and, most importantly for the present paper, that the Methods section seems to wander. Sometimes the Methods will balloon into a whole

paper of its own (Methods papers, in Methods journals); more often it wanders toward the end of the article, after the discussion, where it is printed in a reduced font.

By examining how the arrangement of actual scientific articles diverges from the idealized form articulated in the handbooks, students begin to gain rhetorical control over their own writing strategies. At this point, however, they may continue to think of arrangement only in terms of journal convention. If we press the issue, inquiring into what variations and shifts in such conventions mean, we can extend student freedom and control still further. First there is the question of variation. How are we to interpret it? The first thing my students notice is that putting the Methods after the discussion frustrates the inductive story the research article is supposed to tell. Students first learn where to put the Methods, after all, from the repetitive chronicling that is their laboratory notebooks. Because the Methods must be decided upon before any results are available, the Methods "naturally" precedes the Results just as the Results are "naturally" followed by the Discussion. But by frustrating the seemingly natural progression of the reporting of inductive processes, a focus on the terminal Methods section can highlight the artificiality of all arrangement conventions, including the very ones that determined the practice of the laboratory notebook.

In addition to what might be called its defamiliarization effect, the frustration of narrative noted above forces student readers to apprehend articles by other means, and thus emphasizes the variability of the reading experience in the realm of the scientific article. Gould alludes to a form of this variability in his afterward to Selzer volume mentioned earlier. Commenting on Davida Charney's study of how biologists read "The

Spandrels of San Marco," Gould expresses frustration that trained biologists did not read the article straight through but picked around for salient points. "This bothered me," Gould writes, "because 'Spandrels' must be read as a linear and integral text for maximal effect; it is an essay, not a research report." While admitting that "I never read scientific paper straight through either. I always browse for the key bits first," Gould only briefly mentions that graduate students, unlike trained professional scientists, in fact did read his article straight through. What this suggests, obviously, is that nonlinear, bits-and-pieces reading strategies are *learned*, and that students who get confused when faced with a standard research report haven't yet figured out strategies for effective engagement. In other words, trained scientific readers experience articles neither as unfolding narratives nor as inductive processes, but rather as informational experiences to be consumed piecemeal.

Bruno Latour's concept of stratification in a scientific text, which I briefly raised above, may help clarify this point. Stratification refers to the way an article fortifies itself, not by reference to something outside the text — the commercial source of a purified protein, say, or the methods spelled out in an earlier article — but by an element of the text itself. For example, a claim in an article may refer for support to a figure, which is usually, though not always, a visual representation of results. This figure in turn requires a *legend* to make it understandable, and the drama of internal self-reference continues. Latour's argument is of considerable philosophical interest in the social constructivist view of scientific knowledge, but for the moment the thing to note is that the concept of stratification suggests (although Latour nowhere articulates) a model of reading a

scientific article by going from one layer to the next or "deeper" one. Although one molecular biologist friend of mine claims to read every article he ever cites from title to references, most scientists are not so pure. Trained readers may begin with the title and move immediately to results and discussion; others prefer to go almost immediately to the figures, where the data are presented as compellingly as possible. With the introduction of Medline and other online citation services, it is possible to cite articles by the hundreds without going ever to the library or reading anything but abstracts. Of course, we humanists would never sink so low.

Whatever the particular form of readerly engagement in a particular article, the Methods section will almost never be stratified "shallowly." The deep level of engagement required to make complete sense of it will be beyond the ken of many readers, even those who can make sense of the Results; and others who would be able to comprehend the Methods don't feel it worth the effort — since, they argue, they would never attempt to reproduce the experiment anyway. This somewhat sad fact is acknowledged by Robert Day, who writes in his chapter on the Methods that "Many (probably most) readers of your paper will skip this section, because they already know (from the Introduction) the general methods you used and they probably have no interest in the experimental detail" (36). In this regard, shunting the Methods section to the back of the article may be a simple acknowledgment of how divorced the traditional arrangement of the research article is from most people's reading experience. On the other hand, it may suggest that new scientific specialties are creating more and more papers but fewer and fewer readers able to engage them completely. The question in this regard is whether the new

arrangement marks a real shift in how scientific journals perceive the reading experience. If so, perhaps this shift marks both an attempt to stem the tide of subspecialization and an acknowledgment that in an age of increased pressure to publish, scientists are less and less able to hold conversations, less and less able to engage a text at the deep level the Methods section requires.

In the biological sciences, two of the major journals that publish the Methods after the Discussion are *Cell* and *Neuron*, originally published by the MIT Press and now independently published by Cell Press. *Cell* was founded in 1974 and seems to have started arranging articles this way in its first year; *Neuron*, which began publication in 1988, explicitly stated in its inaugural Information for Contributors sheet that "The Experimental Procedures section follows the Discussion." This sheet also, and I think not coincidentally, called for brief articles four times and trumped the hoped-for rapid pace of review and publication fourteen times. Are these elements — arrangement, brevity, speed — related? After reading the introductory editorial to *Neuron*, I am prepared to say yes. Zach Hall and the other editors acknowledge the "too many journals" are "fragmenting the field and cluttering the literature," but make a case for the need for *Neuron*. This need came about as a result of "the powerful experimental tools that have recently become available" (1). These new methods, the editorial goes on to say, will have significant impact on contemporary neurobiology. In the pages of *Neuron*, "the modern developments in cell biology and biophysics will become important: new electrophysiological recording techniques, novel methods of introducing macromolecules into cells, and recently developed methods of imaging" (1). Yet while contemporary

neurobiology is made possible by the introduction of new methods, the organization of *Neuron* will be "around biological problems rather than experimental techniques." In other words, new methods central to the development of the science represented in the monthly journal will be given no significant place in the journal itself.

If the placement of the Methods after the Discussion is a trend, it's nowhere near universal. For a while during the eighties *The Journal of Biological Chemistry* published long descriptions of methodology (and sometimes figures) after the discussion, in a "miniprint" section which was photoreproduced from author copy; authors who submitted miniprint copy received a discount on page charges for the journal. But the journal soon reverted to the old ways, probably either because Courier miniprint seemed obsolete with manuscripts processed from disk or because it seemed insulting to label a section that the "Instructions to Authors" insisted was "an integral part of the paper" as "Supplementary Material." But for many readers, the Methods is precisely a supplement, a section which both stands outside the textual economy of the article and remains formally integral. In the Methods section, inside and outside meet; stratification and citation are indistinguishable.

In the new pressures put on the arrangement of the scientific research article we are confronted with the what is essentially the hypertextual nature of the reading process in science. These new arrangements may result from changes that include increased specialization and the proliferation of uninteresting articles (again, things that are alien to us in the humanities), but for the student of scientific writing, the trends in knowledge-formation that the new arrangements represent is less important than the opportunities such arrangements offer to writers. The standard cookie-cutter arrangement which places

the Methods between Introduction and Results may attempt to reinforce a certain way of reading the article, but the re-placement of the Methods after the discussion seems to acknowledge that readers are going to read texts the way they want to regardless. Thus, what might be called the cross-manipulation of texts by readers and readers by texts can become a site for active pedagogical engagement and writerly choice.

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